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PENTLAND HILLS

GEOLOGY.

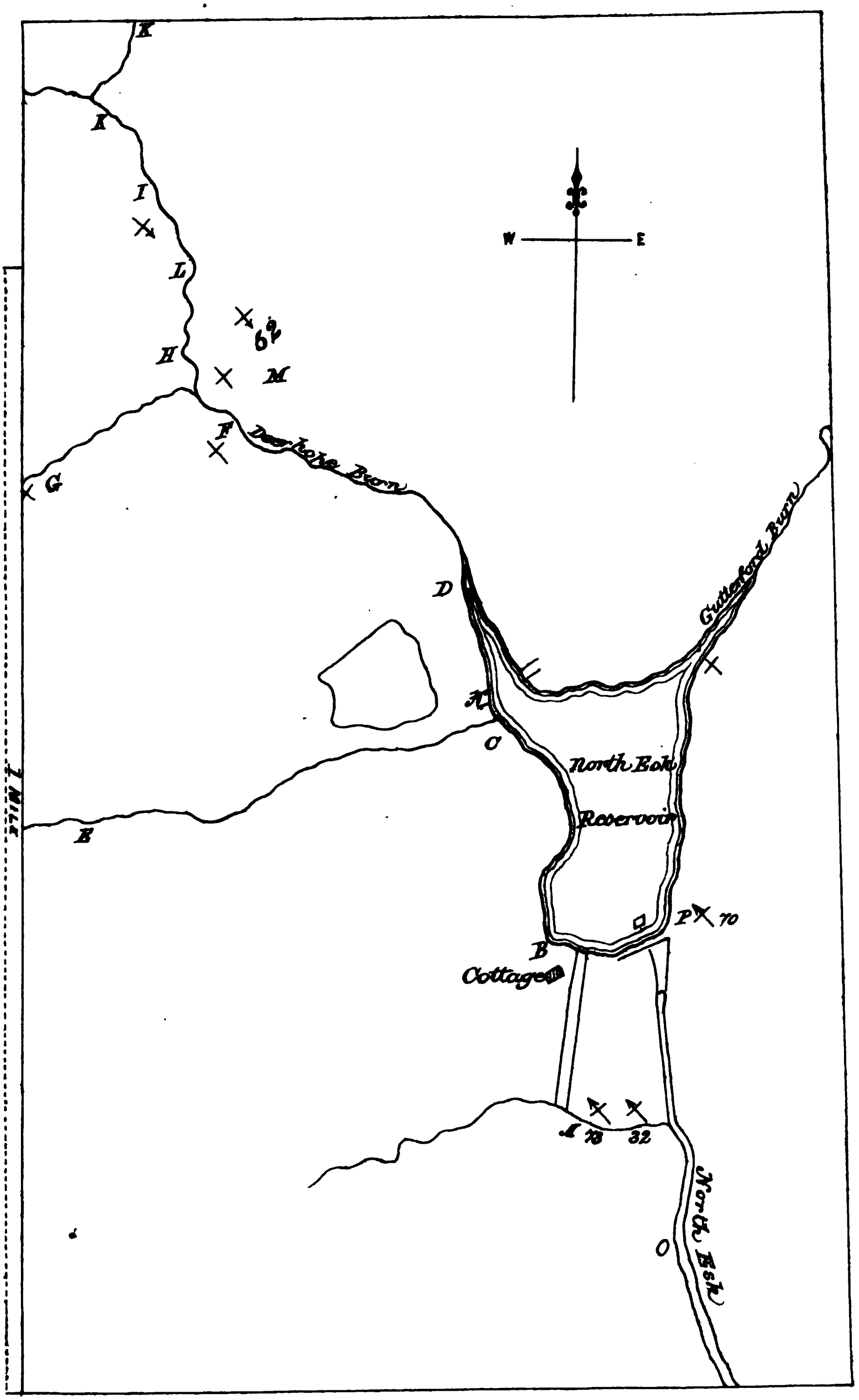
600043037N

Gough Adds Scotland
8° 251.

ERRATA.

Table I., 18th line—rooks, read rocks.
„ 24th line—Diplacanhus, read Diplacanthus.
Page 21, 11th line—these, read this.
„ 24, 31st line—tranverse, read transverse.
„ 27, 10th line—cycle, read sickle.
„ 38, 34th line—to entomis, read to this entomis.
„ 39, 75th line—Petraia Uniserialis, read Petraia Uniserialis?
„ 41, 21st line—Granulosa, read Granulosa?
„ 41, 33d line—*Geikie* should follow Hill in 34th line.
„ 43, 25th line—Zeperdita, read Leperditia.

600043037N


K
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P 70
B
Cottage
A 78
32
North Esk
O
1 Mile

ON THE

SILURIAN FORMATION

IN THE

PENTLAND HILLS.

BY

GEORGE C. HASWELL,
HON. SEC. G. S. E.

WITH PLATES.

EDINBURGH:
WILLIAM P. NIMMO.
1865.

18858. e. 1

[*A Paper read before the Edinburgh Geological Society.*]

BIBLIOTHECA·BODLEIANA·

Dedicated, by Permission,

TO

CHARLES MACLAREN, ESQ., F.G.S., F.R.S.E.,
PRESIDENT OF THE EDINBURGH GEOLOGICAL SOCIETY, ETC.,

AS A MARK OF THE ESTEEM IN WHICH HE IS HELD

BY

THE AUTHOR

AND

ALL GEOLOGISTS.

PREFACE.

My reasons for bringing this subject before the members of the Edinburgh Geological Society and the public are—first, they are the nearest fossiliferous patches of the Silurian Formation to our city, and have therefore a strong claim on the members of the Edinburgh Geological Society; second, they are so little known to the geological world, that most of the eminent geologists with whom I have been corresponding regarding them were quite astonished at their fossiliferous character; and, third, I hope to add one drop to the bucket of geological truth, yet far from full, many thousand such drops being required ere the geological record is complete.

I do not expect that the list of fossils is perfect. I shall have occasion to point out as we proceed many questions in palæontology which have yet to be solved; but if I interest you, and lead others to work in the same field, I shall have attained my object.

BOOKS.

THE books consulted and founded upon in the following Paper, and to which those who wish to go deeper into the subject may refer, are—

Memoir of the Geological Survey of Midlothian, Sheet 32. By H. H. HOWELL, F.G.S., and A. GEIKIE, F.R.S.E. & F.G.S. Appendix to the above by Mr SALTER.

Siluria. By Sir R. I. MURCHISON, F.R.S., F.G.S., &c.

Sir R. I. Murchison's Paper on the Silurian Rocks of the South of Scotland.

Sir W. Logan's Work on the Geology of Canada.

M'Coy's Silurian Fossils of Ireland.

Geology of Fife and the Lothians. By Mr C. MACLAREN, F.G.S.

Barrand's Silurian System of Bohemia.

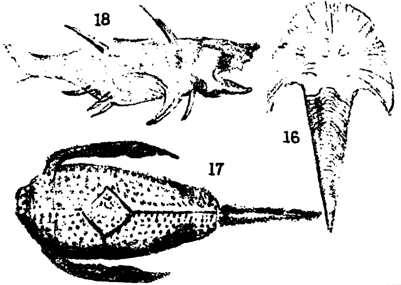
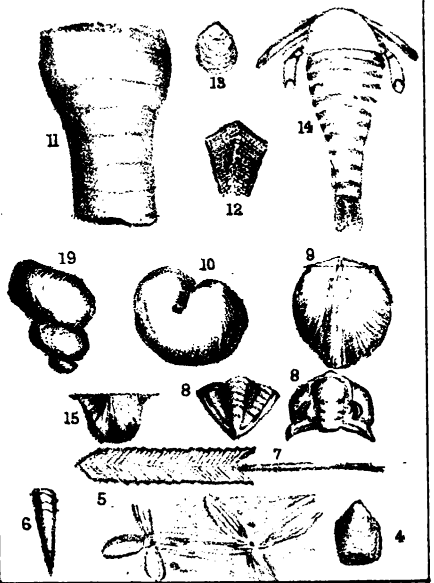
Papers in the *Canadian Naturalist* and *Geologist.*

M'Coy's British Palæozoic Rocks and Fossils.

Monograph of British Brachiopoda. By THOS. DAVIDSON, Esq., F.G.S.

&c., &c., &c.

TABLE I.—Shewing the Order of Succession of the Lower Palæozoic Strata from the Laurentian to the Devonian.

<table>
<tr><td colspan="3">Upper</td><td rowspan="3">Devonian</td><td rowspan="3"> </td></tr>
<tr><td colspan="3">Middle</td></tr>
<tr><td colspan="3">Lower</td></tr>
<tr><td colspan="2">Lesmahago Shales
AND</td><td rowspan="6">Upper</td><td rowspan="10">Silurian</td><td rowspan="10"> </td></tr>
<tr><td rowspan="5">Pentland Hills,</td><td>Upper Ludlow</td></tr>
<tr><td>Lower Ludlow</td></tr>
<tr><td>Upper Wenlock</td></tr>
<tr><td>Wenlock Shale</td></tr>
<tr><td>Lower Wenlock</td></tr>
<tr><td colspan="2">Llandovery</td><td rowspan="4">Lower</td></tr>
<tr><td colspan="2">Caradoc
or
Bala</td></tr>
<tr><td colspan="2">Llandeilo</td></tr>
<tr><td colspan="2">Lingula Flags</td></tr>
<tr><td colspan="4">Cambrian
Rocks</td><td> </td></tr>
<tr><td colspan="4">Laurentian
Rocks</td><td> </td></tr>
</table>

1. Eozoon Canadense.
2. Oldhamia Antiqua.
3. Annellide Burrows.
4. Lingula Davisii.
5. GraptoporaSocialis(Salter)
6. Theca Simplex (Salter).
7. Diplograpsus Pristis (His.)
8. Phacops Apiculatus (Salter)
9. Orthis Vespertilio (Dalm.)
10. Bellerophon Bilobus (Sow)
11. Orthoceras Ludense (Sow)
12. Conularia Sowerbyi (Defr.)
13. Lingula Cornea.
14. PterygotusBilobus(Salt)
15. Orthis.
16. Cephalaspis Lydii (Ag.)
17. Pterichthys Oblonga.
18. Diplacanhus Striatus

DESCRIPTION OF TABULAR VIEW OF THE LOWER PALÆOZOIC ROCKS.

ALL rocks are divided by geologists into two great classes—those which have been formed as sediment in water, and those which have been the result of volcanic action, whether they have been thrown up as basalts and lavas, or have been deposited as volcanic mud in the bottom of a lake or sea. All those belonging to the first are well and distinctly stratified, and are arranged in a regular order of succession, particular rocks being always above or below certain other rocks. From extended observation of the order of succession of rocks, tables have been constructed to exhibit at a glance the relation of any series of rocks to the older and newer formations which underlie and overlie them.

The table (No. 1) of the lower palæozoic strata represents about the half—the oldest half—of the geological scale, beginning with the Laurentian, lately explored by Sir W. Logan in Canada, and extending up to the upper old red sandstone of Duraden in Fifeshire.

In the Laurentian series, which are the lowest sedimentary rocks known, Sir William Logan found last year a minute foraminiferous shell, which, so far as we know, was the first living inhabitant of this world, and at that time its sole occupant. Above the Laurentian comes the Cambrian, in which the only organisms yet found belong to the lower orders of zoophytes and annulosa. Above these lie the silurian. Here life becomes more abundant as well as more varied. In the lingula flags we have a small lingula, a bryozoa, and some other low organisms, to be followed by graptolites in the lowest beds of the Landeilo rocks, and trilobites in its upper beds. In the Caradoc or Bala we have tentaculites, trilobites, brachiopoda, cyclobranchiata, and a coral. Here life, though still of a lowly type, has become more abundant, both in the number of genera and species. In the Llandovery we have much the same genera, with the introduction of a few gasteropoda. In the Wenlock, which overlies the Llandovery, the number of species and genera has very much increased, and although the prevailing type of animal life is still of a very low order, being principally sponges, corals, and brachiopoda, yet we have something like a forecast of the time when the world is to be inhabited by genera of a higher type of development, in the large number of trilobites which have lived in the seas of this period.

These seem to prepare the way for the appearance on the stage of a crustacean of a higher organisation in the upper Ludlow rocks—the pterygotus—large specimens of which have been found at Lesmahago by Dr Slimmon of that town, as well as in the typical district in England. Above the silurian lies the Devonian or old red sandstone formation, the details of which have been so well worked out by the late Hugh Miller. In the passage beds vertebrate life first appears, and we have fishes of curious structure in great numbers in the upper beds. The Pentland Hill series I have represented as not exactly equivalent to any of the subdivisions of the silurian formation of the typical district. It is perhaps partly of Wenlock and partly of Ludlow age. But I will take up this subject again in the sequel when treating of the *age of the series.*

SILURIAN FORMATION

IN THE

PENTLAND HILLS.

INTRODUCTION.

The study of natural history, in one form or other, has been a favourite amusement and recreation from the remotest antiquity —from the time when Adam gave names to the beasts of the field—through the ages of ancient Egypt, Greece, and Rome, when its study as a science was confined to the learned few, down to the present time when it has become fashionable, and every one is expected to be acquainted with at least the rudiments of some of its branches. As at no previous period has there been such a thirst for a knowledge of natural history in all its branches, so natural science never before stood on such sure footing, nor was it ever prosecuted with more liberal-minded zeal. In proportion to the zeal has been the success, and in no department has there been more zeal and success than in geology. When it first became a science no attention was paid to anything but the composition of rocks, the bedding and stratification of rocks, and the question of whether they had been formed by fire or water. All the fossils contained in them received the general name of mineral petrifactions, and they were not examined and studied as the remains of animals, whose organisation was as wonderful as that of any now inhabiting this world, and as capable of arrangement into families, genera, and species, but they were supposed to have been formed by a certain plastic power inherent in the rock itself. It was not then thought that the best standard by which the age of rocks could be decided was by the character of their organic remains. But that this is the case has been abundantly proved by modern researches in palæontology; and now, there is no surer test by which to decide the age of any set of beds than by a thorough examination of their fossil contents, and by a comparison with other strata containing the same fossils, and whose geological age is known. This test we will endeavour to apply to the silurian beds in the Pentland Hills in a subsequent part of this paper.

Mr Geikie's Memoir of the County of Midlothian, with an appendix by Mr Salter, Sir R. I. Murchison's Siluria, and Mr Chas. Maclaren's Geology of Fife and the Lothians, are the only works which contain any published account of these beds. In Mr Geikie's Memoir the description of the beds is very meagre, no doubt from the fact that he had to condense into one thick pamphlet, along with a notice of the volcanic rocks and surface geology, a particular and detailed account of all the beds of coal, ironstone, and limestone, of the *carboniferous formation*, in the county of Midlothian, these being accounted of much more importance, in an economic point of view, than the silurian beds in the Pentland Hills, which yield neither lime nor coal, and not even good building material.

Mr Salter's list and description of the fossils found in these beds is a peculiarly valuable and interesting work, containing, besides mention of formerly described species, many descriptions of new species, and much information regarding the equivalents of this series. He has, however, apparently been limited to one sheet of illustrations, and several new species are left undescribed for want of room to give a figure. Sir Roderick Murchison's notice of these beds in his "Siluria" is confined to some able remarks on the stratigraphical arrangement of these silurian rocks of Scotland, and a description and figure of an orthoceras, *O. Maclareni*, found many years since by our worthy president (Mr Charles Maclaren,) and described originally in his work entitled the Geology of Fife and the Lothians, and the mention that it is probable that the beds are of Wenlock age, from the fact that *Rhynconella compressa*, a Wenlock fossil, had been found in them by Mr Geikie.

This, I think, is all that has been published descriptive of these beds which are very full of interest, both to the palæontologist and to the general geological student. Seeing that so little had been done towards a thorough examination of these beds, I gave the result of my labours to the Geological Society in a paper last session; and having been pressed to publish it by some eminent English geologists, I have agreed to do so,—not because I consider it is entitled to the praise they lavished on it, but because I think that it may supply to local geologists, as well as tourists and geologists generally, a pretty good general idea of the contents of this subdivision of the silurian formation.

In proceeding with our subject, I would divide it into four parts, and describe—

First, The geographical position of this series, and the localities where fossils are most abundant, the lithological character, dip, strike, and general appearance of the beds.

Second, Their relation to the other silurian deposits of Scotland.

Third, The fossils.

Fourth, Remarks on the probable age of this series as derived from the palæontological range of the fossils.

CHAPTER I.

The Geographical Position of the Silurian Beds in the Pentland Hills.

THERE are three separate patches of the silurian formation in the Pentland Hills—one between Bavelaw Reservoir and Harehill; one narrow strip at the head of Loganlee Reservoir; and one, the largest, and the one to which we will devote most of our attention, on the North Esk river and Deerhope burn, covering a portion of the southern extremity of the range.

Suppose we start from the North British Railway station some fine summer morning, by the first train, having taken tickets for Coalyburn, one of the stations on the Dolphington branch, suitably provided with a chipping hammer, a picking hammer or small pick, a compass and clinometer,* a good large haversack, two or three old *Daily Reviews*,—remember *Scotsmans* do not answer so well, as that paper is too hard, and might be apt to crush some of the delicate forms we are likely to meet with in the course of the day. Arrived at Coalyburn, we have a walk of about three miles to the village of Carlops. The road is a straight one, traversing the flat ground which extends from Coalyburn to the base of the Pentland Hills. It passes a good many old and deserted lime quarries, and some which are still in operation. Into these you may take a glance in passing. The limestone, which is of carboniferous age, lies nearly horizontal, and contains specimens of *Productus semireticulata*, *P. punctata*, *Orthis resupinata*, *Chonetes hardrensis*, and is chiefly made up of a mass of encrinite stems.

There is one other point which you might examine in passing.

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* The most simple and useful kind combines both on one dial, and may be obtained from Mr Bryson, the optician, in Princes Street, for a few shillings.

On entering the village of Carlops from the south, the road passes through a small cutting, in the side of which is exposed a bed of bituminous shale of considerable richness. It has not yet been worked, but when the richer beds of Bathgate and Broxburn are exhausted, this at Carlops may be found available for making parafin.

Although I have noticed these carboniferous beds, the excursionist must not linger too long here, else he will have too little time to examine the silurian beds on the North Esk and Deerhope burn.

The village of Carlops, through which we pass, was one of the stages in the coaching days on the mail route to Dumfries. It contains a church and two inns, at one of which, the Habbie's Howe Inn, I stayed a few days; and I can recommend any one wishing to spend a few days in this neighbourhood to take up their quarters here. If they do, they will find a clean, comfortable house, and an attentive landlady.

Taking Carlops as the starting point of the geological part of the excursion, and having got quit of all exuberance of spirits during our walk over from Coalyburn, we will find near the north end of the village a little picturesque stream, which tumbles over rocks in a romantic-looking little glen, past the side of the mill. Here we begin carefully to observe and take note of the geological position of the beds over which we pass. Taking our way up the side of this stream, which is called the North Esk river, we first encounter a trap dyke of considerable thickness, which runs to the north-east along the road about half a mile. It is also seen near the centre of the village, where it is worked for road metal. We then come to old red sandstone conglomerate, standing at an angle of 35°, and dipping towards the south-east. We pass over these beds standing at angles of from 30° to 45° for half a mile, to a point where the stream received a tributary burn. Keep to the right hand stream, and ascend half a mile further, and you are on the *silurian formation.* The junction of the silurian and old red is well worth examining; it is somewhat obscure, but it may be found at a point where there is a paling on the north bank of the river. The old red dips towards the south-east at an angle of 60°, and the silurian dips towards the N.W., at an angle of 45° ; but close to the junction the strata are much twisted, and it is only by ascending to the point A (in the map) that the general dip and strike can be observed. Even here they are very much and curiously twisted. You may examine these beds for fossils. I obtained one specimen of *Orthonota impressa*, and a very fine specimen of *Acroculia antiquata*, but they were in loose pieces, and may have been brought down in the burn during a flood.

On the bank of the reservoir there is a house occupied by Mr John Garnock, who has charge of the reservoir, and excursionists will find him very obliging in lending pickaxes, or directing them to the most interesting points in the sections further up. Advancing on the west side of the reservoir, we pass over the Dictyocaris beds of Mr Geikie, which extend up to a small quarry, (F in the map,) in some of the beds of which some interesting fossils are found. Part of the same beds may be better observed on the east side of the reservoir. At the east end of the barrier the strata are exposed in the face of the hill, and their dip and strike may here be taken: the twisting nature of the strata may also be well observed. The beds consist of fine grained sandstone in thin and thick bands, generally shaley bluish when first exposed, but gradually weathering to a yellowish brown, with shales red, olive-coloured, and dark.

Most of the hard, and some of the soft beds have a peculiar concretionary structure; and in breaking them a prevailing form to lay open somewhat resembles in shape and appearance the carapace of a large crustacean; but this it cannot be, as you sometimes get one ten inches in diameter enclosing one eight inches, which encloses another five, in the inside of which is another three inches, all having the same appearance and outline. They are not nodular concretions, with the matter arranged in circles, but have the stratification sometimes running straight through them, and the peeling seems to be caused entirely by the weathering. I have broken several thousands of these, and have failed to discover any markings which would lead to the belief that they are the carapace of a crustacean. They, however, at some places, as at H, (in the map,) contain numbers of small fossils.

By ascending the burn, C E, some fossils may be found at E, but they are not very abundant. In the quarry at F, *Orthonata amygdalina*, *Platichisma simulans*, &c., are found.

A few yards further on, a small burn flows into the Deerhope burn from the left. Up this burn there is much rock exposed, and here (point G on the map) an obscure specimen of a trilobite, the large orthoceras figured, Plate I., figure 4, *Conularia Sowerbyi*, and great abundance of *Leptæna sericea*, are found. Returning to the mouth of this little burn, and advancing up the Deerhope burn about twenty yards, we come to a little break in the soil, caused by the bend of the burn, (H,) where a yellow concretionary mudstone is exposed. This is full of fossils, and in the course of an hour or two, you may fill your bag with cyclobranchiata, gasteropoda, sponges, zoophytes, and abundance of *Leptæna sericea.* A little further up the beds are much harder, and good specimens are somewhat rare. Specimens of *Atrypa reticularis*, *Holopella obsoleta*, and *Platychisma simulans*, have been found. Further still, (at I,) there is a bed of mudstone scarcely so soft as the first bed of this rock, and without the concretionary structure, in which are found casts of *Rhynconella Maclareni*, a new species, and others. About two yards further up, a bed may be found containing, besides many remains of shells, abundance of tails of trilobites. The heads are somewhat rare, but they are also sometimes found; also fine specimens of *Conularia Sowerbyi*, and a number of other forms. A short distance further, the rocks change colour and become of a red tinge, and consist of sandstone, shale, clays, and sandy shale, all of which are uniformly of a deep red colour, but entirely without fossils. These extend a distance of 500 yards towards the Bore Stone at the head of the burn.

The foregoing description, with the aid of the map, will, I think, lead the geologist to the points where fossils are most abundant, but at other points sometimes good specimens may be found. I will now direct your attention for a few minutes to some of the peculiarities of stratification in this series.

It will be observed that the beds are generally either very highly inclined or perpendicular, and the general direction of the burn is across the strike of the beds, so that if these beds are a continuous series they are nearly 1¼ miles in thickness. Mr Geikie says that this is an ascending series, and that the sandstones at K in the map are the lowest beds of the old red sandstone. Supposing this to be correct, at some points, as at I in the map, we have a backthrow of some degrees.

On the east side of the reservoir the strata are well exposed throughout their entire length. At the end of the barrier the beds dip to the north-west, at an angle of 70 degrees, with the strike N.E. by N. and S.W. by S. Here they consist of crumbling shale, with bands of hard bluish sandstone, which on exposure to the weather becomes softer and yellowish. A little further along the east bank they become more uniformly hard sandstone, and curious hard specimens of crumpling may be picked up. The other beds crossed in walking round the north bank are of much the same character, and fossils are not abundant. At the point N in the map, where a trap-dike crosses the mouth of the burn, the beds are but slightly altered by contact with the trap-dike, and stand nearly at the same angle, and are of similar character till you come to M on the map; here you have the strata in the bed of the stream perpendicular, and above, at a height of twenty-five feet, they are overhanging, and dip to the N.W. at an angle of 52 degrees, so that they have not only been thrown from the horizontal or original position to the perpendicular, but have been thrown back till they form an angle of 52 degrees with the horizontal on the other side; and what is now the lower surface of these rocks has originally been the upper. This is not very evident when standing close to them, but standing over at the quarry F, and looking along the line of their strike, the eye can easily trace the flexture in the shoulder of the knoll. This quarry has not been much worked, but some good beds of sandstone are exposed in it. In the next beds we come to at H, the dip and strike cannot be well observed on account of the concretionary nature of the weathering. The beds at I stand at an angle of 72 degrees and dip to the S.E., and if Mr Geikie is right in his order of succession of the beds, these beds also have been thrown back. The beds here suddenly change character, and become much more sandy and red in colour. They consist of alternate beds of thick and thin bedded sandstone and shale, and may be traced for a space of several hundred yards. They are then overlaid by red sandstone beds, which form the base of the carboniferous system, and dip over the other side of the hill.

The lithological character of this series of the silurian formation is very variable. They are composed of almost every variety to be found in sedimentary rock. We have hard sandstones, soft shales, mudstones as soft as chalk, which cut easily with the saw or knife. Some are brown, some yellow, gray, reddish, and bluish. Some few beds are hard and suitable for building stone, while others are soft and friable. In fact, you have in this section of the silurian formation such a variety of sedimentary rocks as would point to considerable changes of the circumstances and conditions under which they have been deposited. Many of the beds which are fossiliferous have apparently been deposited in shallow water (as at G,) as evinced by the proportionally large number of gasteropoda found, which usually live in much shallower water than the brachiopoda.

CHAPTER II.

Their Relation to the other Patches of the Silurian Formation in Scotland.

Sir Roderick I. Murchison in his "Siluria," gives a diagram to show the general relations of the silurian beds of the south of Scotland; but at the time that was drawn, the materials from which it was constructed were not sufficient to show the relation of the beds of Peeblesshire to those of the Pentlands, and our information regarding the Peeblesshire beds is still very imperfect. This much we know, however, that the silurian formation there is almost composed of a series of anticlinal and sinclinal axes; and as it is divided from the silurian of the Pentlands by a space of ten or twelve miles of overlying carboniferous and old red sandstone strata, no evidence of a reliable nature as to the probable age of the Pentland Hill series can be derived from thence—at any rate until the geological survey of that county is completed.

The series of beds exposed in the Pentland Hills are cut off also from all connexion with any beds to the north by the whole breadth of the central Scottish coal-field, and the nearest point at which the silurian formation appears in this direction is near to Callander,—too far to be of any use in determining the probable age of this series. On looking in the direction of the strike of the beds, however, we find, at Lesmahagow, shales of the age of the upper silurian or upper Ludlow rocks, from which Dr Slimmon has obtained magnificent specimens of Pterygoti and other upper Ludlow forms. These beds, however, occur a few miles out of the line of the strike, which varies in the Pentland Hills from N.E. and S.W. to N.E. by N. to S.W. by S. That the beds are allied there can be no doubt, but that the one are the exact equivalents of the other, judging from the nature and composition of the beds, there seems sufficient reason to doubt. When we come to consider the fossils we will see that there is still further reason to hesitate before deciding that they are the exact equivalents, and we may find that the palæontological range of the fossils is such as would indicate that they belong to two different zones of deposit. One of them, perhaps, of the age of the Ludlow rocks, and the other of the age of the Wenlock shale.

Regarding the position in which these strata were originally deposited, and their present position, I should like to say a few words. The now vertical strata of these series, like all other sedimentary rocks, have originally been horizontal, and have, by lateral pressure, probably, been contorted, as shown in diagram No. 2; after which they have been subjected to the effects of denudation by water or ice. Some of the twistings are to be seen in different parts of the Deerhope burn section. At A, in the map, there is a very picturesque little ravine, which is scarcely visible until you are on its brink, in which a very wonderful sinclinal axis is seen, as at Q in the diagram No. 2. The geologists who visit this little ravine may have some of their views extended by a study of this sinclinal axis, and tourists and pic-nic parties to Habbie's may look with wondering eyes to see, in the space of a hundred yards, beds of rock of an aggregate thickness of some hundred feet bent and twisted in every direction, like sheets of paper,—so wonderful are the powers of nature when displayed in all their grandeur. At M, in the map, a portion of what may have formed part of an anticlinal axis, as at R in diagram No. 2, is well displayed on the side of the hill, where the strata project from the heather at an angle of 52 degrees with the horizontal.

Subsequent to the time when the beds were folded, as in the diagram No. 2, they have been subjected to denudation, which has swept away most of the anticlinal axes, and on the edges of the vertical silurian strata the old red sandstone has been deposited. Mr Charles Maclaren, in his Geology of Fife and the Lothians, gives a section of these beds, in which he represents the relation of the silurian to the old red sandstone in his usual plain but striking manner.—(See diagram No. 1.) The red sandstone beds at D and M were no doubt continuous; those at C may also be an extension of the same beds. The removal of the red sandstone from *d g* and *h* has been effected by the agency of ice and river action. That the silurian has been subjected to denudation previous to the deposition of the old red sandstone, and underlies it in this part of the Pentlands, is evident, because, wherever there has been much denudation, as in some of the glens, there the silurians are exposed; but generally, when we ascend the hill-sides, except at Cockrig, we lose the silurian beds, to find them again perhaps in the next river course, as if the mantle of red sandstone had originally covered all the silurian rocks in the form of a plateau, which has by denudation been worn through in some places so as to expose the edges of the vertical silurian strata which lie below.

At South Dean Hill, on the river Jed, in Roxburghshire, at a distance of thirty miles from the Pentland Hills, in a southerly direction, the vertical silurian strata are exposed, overlaid by horizontal red sandstone beds similar to that of the Pentland Hills. This section was described by Professor Nicol in the *Geological Journal*, vol. iv., page 199, in which he gives an illustration. The position of the upright silurian rocks, which there are of lower silurian age, capped by the horizontal red sandstone, bear a somewhat remarkable similarity to what Mr Maclaren represents as found in the Pentlands,—so remarkable that it can best be explained by the supposition that the sandstone was deposited at the same time and under similar circumstances. During the old red sandstone period the Pentland Hills and the south of Scotland have been covered by an ocean of great depth, the bottom and islands of which were formed of the upturned edges of the silurian strata. On these, in the course of ages, the old red sandstone was deposited, which in turn was elevated from its original position by a series of movements to that which it now occupies in the Pentland Hills and this part of Scotland.

CHAPTER III.

*Fossils.**

Although some remains have been found which somewhat resemble fish plates in the sandstone bed of the quarry situated at the point marked F on the Deerhope burn, about 700 yards above the reservoir, yet they are so ill preserved that little can be made of them, and we cannot even say that they are fish plates. Evidence of the existence of fish in this deposit being wanting, the highest order of animals which we have to describe are the cephalopoda.

CEPHALOPODA.

Orthoceras Maclareni.

Plate I., figure 2.—This cephalopod was found by Charles Maclaren, and described by him in his Geology of Fife and the Lothians. It is usually found in fragments from half an inch to two inches long, tapering slowly, and varying from an inch to one inch and a quarter in diameter. The septæ are rough, imbricated, swelling at the joints, and close together, varying in distance from three-quarters to one and a quarter lines. Mouth oblique. It is easily distinguished from the next species.

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* Fossils.—I have represented in plates 1, 2, and 3, all the fossils mentioned by Mr Salter, and all those found by members of the Society, as well as those I have found myself. The drawings may not be so perfect as if drawn by an artist, but although perhaps wanting in artistic excellence, they are, I think, very correct.

I have not succeeded in finding any old collection of these fossils anywhere in Edinburgh, and I cannot ascertain that any collection, to any extent, had been made until a few years since, when Messrs Ramsay, Geikie, Salter, and Gibbs made the collection for the Geological Survey. As I have not access to that collection, all my figures are taken from specimens collected by members of this Society; and I beg to acknowledge to Messrs James Haswell, Henderson, Brown, and Will, my feeling of gratitude for the assistance I have received from a study of their specimens.

Locality, H, &c.

ORTHOCERAS POLITUM—*M'Coy.*

Plate I., figure 1.—This species is easily distinguished from the following by the distance between the septæ being more than half the diameter of the shell. Length, when perfect, nine inches or more, width at mouth one and a quarter inches, regularly tapering, smooth.

Locality, I.

ORTHOCERAS SUBUNDULATUM.

Plate I., figure 14.—This species has the septæ distant less than half the diameter of the shell. It measures about eight inches long, and half an inch to one inch thick when perfect, but specimens are more common about half that length.

ORTHOCERAS.

Plate I., figure 15.—Somewhat like the preceding; but the septæ are usually only three-fourths of a line distant, smooth, and rounded at the joints. A small species.

Locality, I.

ORTHOCERAS SPECIES.

Plate I., figure 4.—This specimen may not be an orthoceratite, and it is placed conditionally under this head. I have given an exact representation of the specimen which was found by Mr Henderson. It is like a cephalopod, although quite different from any species described. It might, perhaps, with more justice be placed under theca; but the triangular shape does not appear in my specimen. It is five inches and a half long, by one inch and three-quarters broad at the upper portion; tapers gradually to one inch at the lower end. Subcylindric, covered with rather indistinct tranverse wavings, which are crossed by eighteen longitudinal striæ, one-eighth of an inch apart; between each of which, as shown in another specimen, are two narrower lines. About the middle is a curious convex belt.

Locality, G.

ORTHOCERAS (CYCLOCERAS) TENUIANNULATUM—*M'Coy.*

Plate I., figure 3.—About half an inch in diameter, convex, tapering slowly. Joints formed by imbricated convex rings with spaces between more than double the width of the belt.

Specimens of this are not common; but those I have found appear to differ from *O. Maclareni* in the much greater width between the septæ, in proportion to the thickness, and to agree pretty closely with M'Coy's species *Orthoceras* or *Cycloceras tenuiannulatum.*

GASTEROPODA.

ACROCULIA ANTIQUATA—*Salter.*

Plate I., figure 11.—This species is distinct from *Acroculia haliotis* of the upper Ludlow rock. It is broader, and is marked with deep lines of growth, which are crossed by fine striæ. The spire is small and depressed, almost concealed.

Locality, points marked L and A in the map.

EUOMPHALUS FUNATUS—*Sowerby.*

I have not succeeded in getting a perfect specimen of this shell. It seems, however, to be the same as figured in Murchison's "Siluria," (Plate XXV., fig. 3.) It is a shell of two to three whorls, conical, rounded, and spire depressed. Each volution is marked by six or seven thread-like ridges, crossed by indistinct lines of growth. It appears to have been a thin shell, and occurs usually in fragments.

Locality, H.

PLATYCHISMA SIMULANS—*Salter.*

Plate I., figure 6.—" *Subdiscoid* (*helicoid*) of four whorls, which are each very little convex, except just below the suture, the outer or body whorl once and a half the width of the preceding. Beneath, the whorl is nearly flat, the outer angle, therefore, is somewhat acute, and has a distinct marginal ridge. In the specimen figured, (by Mr Salter,) this shows like a band ; and, if such were really present, it would make it a pleurotomaria. Umbilicus small, not above a quarter the width of the shell, which does not reach more than half an inch diameter."* I found one specimen three-quarters of an inch diameter ; but the usual size is under half an inch. There is no trace of a band in any of my specimens, so that I can confirm the opinion of Mr Salter, that this shell should be classed under platychisma.

Locality, F and L.

CYCLONEMA SALTERI—*New Species.*

Plate I., figure 9.—Spire conical, with one side of the cone straight, the other curved. Spire of the same length as the aperture. Whorles (four to five) very convex, and much rounded. Seven to eight narrow distinct thread-like ridges ornament each, crossed by fine striæ. This shell is distinguished from *C. corallii* by the more rounded or inflated character of the shell, as well as by the markings being narrow and thread-like, but sharp and distinct.

Locality, H.

HOLOPELLA OBSOLETA—*Sowerby.*

Plate I., figure 8.—Shell conical and acute, spire lengthened, six to eight whorles regularly tapering. Apical angle about 30°. There are no lines of growth visible in any specimen I have seen, but it agrees so closely with specimens from the upper and lower Ludlow rock, that I think there can be no difficulty in referring this species to *H. obsoleta.*

Locality, I.

HOLOPELLA TENUICINCTA.

Plate I., figure 7.—Spire very much elongated, of about twelve whorles. Apical angle 20°, about nine lines long, whorles not inflated, suttures narrow, sharp, and simple. This shell is apparently rare. Mr Salter mentions it as such, and I have found it only in one thin band, about four inches thick, in the soft yellow mudstone above the quarry.

Locality, H.

BELLEROPHON, &c.

Specimens which may be referred to bellerophon are abundant, but they are usually so much crushed that they cannot be specifically determined. The same may be said of a very prevalent form resembling goniatites, figure 13.

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* Salter.

Also one specimen of *Maclurea*, like *macrothalma*, was obtained in the bed at I. (Plate I., figure 13.) It is slightly crushed, but is entire. I think it may with safety be referred to this species.

PTEROPODA.

CYRTOLITES—*New Species.*

Plate II., figure 4.—Cycle-shaped, but not much incurved at the point. About one inch long, two-tenths of an inch wide at the mouth, regularly tapering, convex, subcylindrical. Lines of growth, distant, slightly curved, and not conspicuous. This is evidently a new species.

I have procured only one specimen, showing the entire shell.

Locality, G (rare.)

CONULARIA SOWERBYI—*Defrance.*

Plate II., figure 1.—Of this species a few specimens have been found, of which some are very perfect, and show all the markings perfectly preserved. I have one specimen showing the quadrangular shape, two sides being perfect, and the other two somewhat crushed.

Locality, G H, and very fine specimens at I.

CRESEIS FORBESII.

Plate II., figure 2.—Shell smooth, and very thin; shape conical, diminishing rapidly towards the apex; finely marked, with rather distant transverse striæ, and with a deep longitudinal depression, but margin of aperture apparently not prolonged superiorly.

There is a very common form which I think may be referred to this genus and species. It usually occurs in fragments about an inch long, and generally as casts of the inside of the shell.

TURILLEPAS WRIGHTII—*H. Woodward*—Plate IV., figures 12, 13.

THECA.—An undetermined species.

Plate II., figure 3,* is the figure of a specimen of a crustacean which is new to these beds, if not to the science. Only one specimen has been found. I therefore forbear to give it a name until it is illustrated by more perfect specimens. †

LAMELLIBRANCHIATA.

LUNULOCARDIUM ELEGANS ‡—*Salter*.

Plate III., figure 18.—"Lunulocardium (Munster) semiuncialis et ultra, subtrigonum, convexum, per totum radiatostriatum, latere postico haud valde angulato nec elongato, latere antico producto angusto. Umbo subcentralis. Striæ medianæ latiores. Lineæ incrementi irregulares, distinctæ."

"I am compelled to adopt Munster's very imperfectly defined genus. It appears to include a number of thin hingeless shells, with a shape and sculpture much like cardium, to which in all probability they are nowise allied. It is probably nearer to cardiola. The genus seems a necessary one to include many silurian forms. They have always prominent anterior (rarely subcentral) beaks, a carina down the posterior slope, and a more or less evident lunette anteriorly. The shell is very thin.

"The genus is upper Devonian, according to Munster. The silurian species we refer to are both lower and upper silurian —chiefly the latter.

"There are several unpublished forms in the upper silurian rocks; but the one nearest to ours is a species with finer striæ, a much more lateral beak overhanging the anterior third, an angularity proceeding vertically from the beak to the front margin, and *no* lines of growth visible.

"The subcentral beak, rather coarse central striæ (the remainder cover the whole surface,) and strong irregular lines of growth distinguish this species easily."

Locality, F.

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* This figure has been accidentally omitted from Plate II.

† Since the above was in type, Mr Brown has discovered some similar forms in the Moffat shales, but they are probably not specifically identical.

‡ Mem. Geo. Survey, Sheet 32, page 139.—*Salter*.

I have given the preceding description by Mr Salter, who found and named this species from the Pentland Hills. It has not been found elsewhere.

ORTHONOTA BULLA—*Sowerby*—(*variety Gentilis*, *Salter.*)

Plate II., figure 7.—This shell is transversely elyptical, twice as broad as long. Near to the anterior end is the beak, and between the beak and the anterior end a small depression. The posterior end is rounded. Lines of growth distinct. Shell smooth.

Locality, H.

ORTHONOTA AMYGDALINA.

Plate II., figure 12.—Rather smaller than the last, without the lateral depression. Posterior extremity rounded. A shallow sinus runs from the posterior extremity nearly parallel to the hinge line.

Locality, H.

ORTHONOTA IMPRESSA—*Sowerby.*

Of this species only one specimen has been found, the one figured in Plate II., figure 14. It is unfortunately broken at the anterior end, but is otherwise entire, and represents both valves. The distinction between this and the preceding species is so marked that they cannot be confounded. The depression on the side of the valve, instead of being close to the anterior end of the shell, (see Plate III., figure 1) is at almost an equal distance from the anterior and posterior extremities.

Locality, O.

ANODONTOPSIS BULLA—*M'Coy.*

Plate II., figure 10.—Size a quarter of an inch in diameter; round, nearly circular; hinge line shorter than the width of the shell; beaks oblique; small lines of growth, fine but distinctly seen with a pocket lens. In this species, the lines of growth are small and close together. There is also another species found in the Pentland Hills, figure 3, with very much bolder markings.

Locality, H.

ANODONTOPSIS LUCINA—*Salter.*

Plate II., figure 9.—" Orbiculari-quadrata, compressa, quam longa paullo latior, antice et postice truncata, nate subcentrali arcuata; equo carinae duae, postica angulata marginem ventralem attingens, antica obsoletior. Superficies rugis concentricis crebris lineisque radiatis nonnullis ornata. Long. 7 lin." *

This shell will be easily recognised by the smooth parallel lines of growth, and by the shell being longer than broad, and two shallow grooves radiating one from each side of the beak.

Locality, H.

CTENODONTA OBESA—*Salter.*

Plate II., figure 5.—" Semiuncialis, transversa, ovata, inflata, sublævis, latere postico brevissimo subacuto, nec carinâ sejuncto. Margo ventralis convexus, vix sinuatus. Nates depressi curvi."†

Locality, H.

CTENODONTA THRACIOIDES.

Plate II., figure 6.—" Modica vix semiuncialis, lævis, transversa, oblonga, haud convexa; nate subcentrali eminente. Latus anticus longior rotundatus posticus truncato-quadratus, carinâ obtusâ a disco sejunctus. Margo ventralis subrectus, haud sinuatus."‡

There is found also a small smooth shell which may be referred to this genus. It has apparently been a very thin shell, and good specimens of it are rare.

BRACHIOPODA.

MERISTA MACLARENI—*Haswell.*

Plate II., figure 16.—Of this brachiopod only one specimen has been found. I could find no description of it anywhere, I therefore sent it to Mr Davidson of Brighton and wrote him on the subject: he says, "It is probably a new species, as I do not find it figured in Sowerby's Silurian System, M'Coy or Barrandes' works." I have, therefore, out of compliment to our present president, who in his younger days was the first discoverer of these beds, named it "Merista Maclareni."

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* See page 140 of Mem. Geo. Survey.

† Ibid., page 141.

‡ Ibid., page 141.

Specific Character. — The ventral valve, (larger valve,) has a smooth much incurved angular beak with well defined beak ridges. Shell smooth without striæ; lines of growth indistinct. An angular sinus commences a short distance from the beak and extends to the front. Shell oblique, hinge line short, dorsal valve not so deep as the ventral one.

Locality, I.

This species is found far up the Deerhope burn, not far from where the beds become reddish.

RHYNCONELLA COMPRESSA—*Sowerby.*

This species was found by Mr Geikie in the Pentland Hills near to Bavelaw Reservoir.

RHYNCONELLA PENTLANDICUS—*New Species.*

Plate III., figure 5—Represents a species of Rhynconella which is mentioned by Mr Salter, but owing to the imperfection of his specimens he gives it no name. It is apparently different from any published form. Having found more perfect specimens I am able to decide that it is not Wilsoni, neither is it angustifrons. I propose to call it *Rhynconella Pentlandicus* in this paper.

Oblong pointed towards the beak, ventral valve convex, with apparently an angularity running down the middle, striæ numerous, continued across the entire length of the shell, beak prominent, recurved. Dorsal valve slightly convex.

Locality, H and I. Very abundant at I.

RHYNCONELLA PENTLANDICUS— *Variety.*

Plate III., figure 10.—In the bed at I, a rhynconella occurs, which may be considered a variety of the preceding.

Specific Character.—Shell irregularly pentagonal, nearly as broad as long, not very deep, ventral valve convex, dorsal valve concave, striæ numerous, most distinct, towards the margin lines of growth distant. Hinge line short.

RHYNCONELLA SEMISULCATA.

Plate III., figure 4.*—Only one specimen of this shell has been found, and that one not very perfect. So far as it can be seen in that specimen, it agrees with the description of semisulcata. 13-15 angular ribs, of which three occupy the sinus, lines of growth are strongly marked, ventral valve convex, ribs extending across the valve to the hinge. Shell broader than long.

Locality, H.

RHYNCONELLA.

Plate II., figure 15.—This species is readily distinguished from the last by having only two ribs in the sinus and the ribs being only developed at the margin, leaving the top of the ventral valve plain, perhaps smooth, ribs about seven. Shell longer than wide—irregularly pentagonal. Of this shell only one specimen has been found, and that one, unfortunately, is not very perfect. It is, however, distinct enough to show that another species of rhynconella should be looked for.

Locality, H.

ATRYPA.

ATRYPA RETICULARIS—*Dalman.*

Plate III., figure 2.—*Specific Character*, (*Davidson.*)—" Shell oblong ovate, widest near the hinge; beak small acute, very little produced, incurved, and often pressed to the umbone of the ventral valve, so that the small circular foramen situated under its incurved extremity is rarely perceptible. Dorsal valve uniformly convex, at times gibbous, and without any definite fold, but becoming slightly concave towards the cardinal extremity on either side of the umbone. Ventral valve much less convex and deep than the opposite one. Convex at the beak and along the middle, but becoming gently concave towards the lateral portions or margins of the valve; front margin a little advanced, indenting that of the dorsal one. Surface of valves ornamented with numerous small radiating rounded ribs, which continually augment towards the margin by means of bifurcation, or by the interculation of ribs at various distances from the beaks. The surface is also closely intersected or crossed by numerous fallacious expansions in the shape of plaited laminæ or frills." This species is very variable, and many specimens may be found which might almost be considered as varieties, were it not that specimens may be obtained forming a chain of connecting links between the typical species, and these varied specimens.

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* Geological Survey of Great Britain, vol. ii., plate 20, figs. 1-8.

Localities, B, F, G, H.

ATRYPA—*Species.*

Plate III., figure 6.—There is a small species of atrypa, of which I give a figure, Plate II., figure 14. Its character cannot be made out with certainty, as only one specimen has been found; and although that one is well preserved, yet it represents only the cast of the ventral valve. I have given the figure to enable collectors to recognise it when it turns up to their hammer, and from more perfect specimens its character may be made out. So far as we can see it is circular, with the hinge line about half the width of the shell, ribs about twenty-four, lines of growth very prominent, distant.

Locality, H.

STROPHOMENA RHOMBOIDALIS—*Dalman.*

Plate III., figure 3.—Shell semicircular, hinge line longer than the width of the shell. Striæ numerous, fine, radiating, crossed by semicircular irregular depressions, parallel to the margin. Shell nearly flat, except towards the margin in adults.

This shell ranges from the lower silurian to the carboniferous. Mr Thomas Davidson says regarding it, " The ventral valve is geniculated, or in other words but slightly convex or flattened up to a certain age, when the valve becomes suddenly deflected downwards at nearly right angles. The margin is undulated, concave near the cardinal angles; it afterwards bulges out, to form in front another slight inward or outward curve. On the flattened portion of the valve, there exists a variable number of slightly undulating and irregular concentric wrinkles, which turn outwardly towards the cardinal angles, and thus follow the marginal curves. The entire surface is covered with threadlike radiating striæ, and a small circular foramen is generally observable in the young up to a certain age, when it becomes obliterated or cicatriced in the adult."

Locality, B, small specimen at H.

STROPHOMENA APPLANATA—*Salter.*

Plate II., figure 18.—This species is one of the prettiest shells found in these beds.

Each valve semicircular with projecting ears, almost flat except at the beak, which is slightly elevated, covered with about forty principal radiating striæ, between each pair of which is another extending from the margin about half-way to the beak, hinge line long and straight, no lines of growth visible. My figure is taken from the cast of the ventral valve. Lines of growth are indistinct.

This species may be readily distinguished by the narrow thread-like shape of the striæ and the pectinated appearance of the margin of the shell.

Locality, H.

ORTHIS ELLEGANTULA—*Dalman.*

Plate II., figure 19.—Size, from one-fourth to half an inch, usually about one-third. The fine striæ are sometimes very well preserved.

Locality, F, G, and H.

ORTHIS MITCHELINI *or* REVERSA.

Plate III., figure 8.—Several specimens of a brachiopod resembling either of these species have been found; but until more perfect specimens are procured, the question whether it belongs to either of these species or to a new species cannot be decided. Size, from three-quarters of an inch to one inch and an eighth in diameter, a little broader than long, front broad and nearly straight, shell convex, covered with close equal radiating striæ—rare.

ORTHIS MINUTA—*New Species.*

Plate III., figure 1—(*Enlarged.*)—*Specific Character.*—Transversely semicircular, hinge line short, with 24 (?) principal ribs, radiating, between each pair of which is another rib nearly as prominent; towards the margin a third set of ribs is sometimes visible; lines of growth indistinct, ventral valve slightly concave.

"Allied to *O. caduca* (*Barr*) and to *Orthis testudinaria*, but is distinct from both."—*Davidson.* This is a very beautiful shell when magnified.

Locality, H.

LEPTÆNA.

LEPTÆNA TRANSVERSALIS—*Low.*

Plate II., figure 17.—I am not quite certain that this is *transversalis;* it is described by Mr Salter as *L. transversalis*, but I think that many of the specimens are nearer to *sericea*, the fine striæ between the principal striæ being shown generally in both valves. The inside of the shell is covered with many minute prickles, which leave the cast full of small holes like pin points.

It may be that this variable little shell is only a variety of *transversalis*, yet I think that both species may occur in the Pentland Hills.

Since writing the above, Mr Thomas Davidson, F.G.S., has examined the specimens collected by the Survey, and has decided that they are *Leptæna sericea.**

Locality, G, H, &c.

CRUSTACEÆ.

PTERYGOTUS BILOBUS—*Salter.*

Plate II., figure 20—Is a drawing of the only specimen, I believe, which has been obtained in this locality. It consists of six of the annular rings of the body, and what may be the half of the bilobed tail out of its socket. One of the rings near the top of the specimen has been drawn out of the one which should overlap it, and a rim at the top of the annular ring is exposed, similar to those in the body of the common lobster, and to which the muscles are attached which regulate the motion of the tail. I have given also in Plate III., figure 9,* a restoration of the entire animal, to enable any one finding any other part of this species to identify it.

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* Mr Thomas Davidson of Brighton is at present working at, and will shortly publish, his monograph of the British Silurian Brachiopoda, in which he will describe the brachiopoda from the Pentland Hills, and I have to refer geologists who wish further information on this subject to that able work.

Locality, N.W. slope of the Pentlands, near the Bavelaw Reservoir.

PTERYGOTUS ACUMINATUS—*Salter*.

Mr Salter found a swimming paddle of this species at Deerhope; but as I have not yet seen any specimen from thence, I have not given a figure of it, being anxious to give no figures of any species except exact copies of actual specimens found there which I have seen. I have, however, found the serrated base of a jaw-foot, but apparently of a smaller species.

TRILOBITES.

ENCRINURUS EXPANSA—*New Species*.

Plate IV., figure 4.—This species which I have figured is, so far as I can ascertain, undescribed.

It has a pear-shaped glabella rounded in front, and narrowing slightly towards the neck segment, before which are two cephalo thoracic furrows, indentations at each side, each extending across the glabella one-fourth of its width.

Glabella studded with about twenty-eight small tubercles; front of the glabella rounded, a row of tubercles running parallel to the margin; cheeks convex triangular, with the sides nearly equal; eyes lateral—much projecting; head convex; body but slightly tapering; eleven rings; pleuræ bend downwards; pygidium somewhat quadrangular, pointed. Pleuræ bent downwards—the last one nearly perpendicular. Axis of pygidium smooth in the centre, with transverse markings at the side, two of which correspond to one of the pleuræ. The discovery of the first specimen of this species is due to Mr Salter, but his specimen was so imperfect that he did not describe it.

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* Of the Illustrations for my Lecture.

Locality I, in abundance.

PHACOPS STOKESII—*Edw.*

Plate IV., figures 6, 7.—Of this species I have not yet seen any perfect specimen from this series of beds. The pygidium (tail) is not uncommon in the hard grit at G; and Mr Powrie of Reswallie found a very fine specimen of an eye, (in H,) showing all the facets most distinctly, and quite as sharply defined as if the animal had only recently died.

ZETHUS PAGEI—*New Species.*

Plate IV., figure 1.—Size of the head from three-eighths to three-fourths of an inch long, measuring from the central point in the front to the produced ends of the lateral angles. Of this species only the cheeks and eyes have been found, but in four of my specimens these parts are beautifully preserved. If we suppose a narrow glabella similar in shape to those of allied species, we will have the cephalic shield semicircular or almost semi-elyptical. The cheeks are somewhat triangular, flattened cephalic shield and cheeks coarsely tuberculated. Entire surface covered with minute prickles. Eyes prominent, large for this genus, very convex, situated close to the interior margin of the cheeks, sometimes looking as if they thus indented the glabella. Facets very minute and numerous, each eye having from nine hundred to one thousand.

Locality, I.

GENUS ENTOMIS.

ENTOMIS TUBEROSA—*Jones.*

This species was found by Mr Salter, and described by Mr R. Jones.

" Valves sub-oval; in one specimen three-sixteenths of an inch long and two-sixteenths of an inch wide; in a specimen from Bow Bridge, Ludlow, one-fourth of an inch long and one-sixth of an inch wide. Dorsal margin nearly straight in the middle third, and curving off rapidly at the ends. Ventral margin rounded; most convex in the posterior third. Extremities rounded; the anterior narrowest.

"The transverse sulcus is strongly marked, curving forwards, and indenting nearly three-fourths to the width of the valve. Anterior to the furrow, and within its curve, the surface is raised up into a round tubercle." Mr Jones writes me regarding this fossil, which is extremely rare—" I should like to see some good specimens of *E. tuberosa.* Those from the Pentlands are more or less distorted. One from Australia is the best I have seen." This little crustacean has had a very wide range, having lived in the silurian seas both in the northern and southern hemispheres.

ENTOMIS IMPENDENS—*New Species.*

Plate III., figure 11.—I found the internal casts of a small entomostraca one-fortieth part of an inch in diameter. At first I thought that this might be *Beyrichia Klœdeni*, and sent a specimen of it to Mr R. Jones. Mr Jones thought it might be *B. Klœdeni*, but was not quite certain. I then found some casts of the exterior of the valve, and found that it differed essentially from *Beyrichia Klœdeni.* In this opinion Mr Jones concurred, and proposes to describe it as a new species of entomis, provided he could make enough of the distinction.

Specific Character.—Bivalved, each valve semicircular, ventral margin bent near the middle, and slightly flattened before and behind the bend. A deep sulcus extends from the dorsal margin across the shell to one-fourth of its width from the ventral margin. There is a small tuber observable in some specimens on the incurved side of the sulcus, *i.e.*, anterior to the sulcus, but more generally round the sulcus there is a very slight ridge, as if produced by a thickening of the shell. Sometimes it is seen quite round the sulcus, but usually it is more distinct at one side than the other. Specimens may be found variable in outline. Shell convex.

This is extremely like *E. tuberosa,* from which it is distinguished by its size. *B. Klœdeni* is similar in size and outline to entomis, but the sulcus is not linear, but nearly hemispherical, and has a large central tubercle. *E. tuberosa,* again, is distinguished at once by its size, being a quarter of an inch across, while the other two are only from one-thirtieth to one-fortieth of an inch.

BEYRICHIA KLŒDENI—*M'Coy.*

Plate III., figure 12.—Specimens exactly agreeing with Professor M'Coy's figure (see "British Palæozoic Rocks and Fossils") are found in a soft mudstone which occurs in rolled fragments in the reservoir. It is associated with specimens of Leptæna and other shells which occur in this series, and although I have not succeeded in tracing these fragments to the bed from which they have been derived, yet there can be no doubt that they belong to some bed in the course of the burn, and have been brought down by the stream.

THECA.

The last of the crustaceans to which I have to refer is Plate II., figure 8, of which specimens are to be had plentifully in the mudstone of the Deerhope burn, but generally in such an imperfect state of preservation that the species cannot be decided.

PROTASTER SEDGWICKII—*Forbes.*

I have given (Plate II., figure 21) a figure from the memoir of the Geological Survey, from a specimen found by Mr Gibbs. The specimen is, however, very obscure, and it is referred to protaster by Mr Salter with some degree of doubt.

ANNELIDA.

ANNELIDE BURROWS are not uncommon, but as they contain no markings, can scarcely be classed.

ZOOPHYTA.

PETRAIA UNISERIALIS.

I give a figure of a specimen of petraia, very like *P. uniserialis* of M'Coy. The cup is shallow, and the inside marked with fine radiating, straight, distinct striæ, but better specimens should be found before the species be decided.

FAVOSITES ALVEOLARIS—*Goldfuss.*

Plate IV., figures 17, 18.—"Corallum forming large irregular masses, or small hemispherical expansions, with concentrically wrinkled, flattened base, impressed by the rhomboidal slightly oblique bases of the tubes. Tubes from four to six angled, the latter being adult with the average diameter of one line, the former being the young tubes which are few and smaller. Diaphragms flat, irregularly indented or undulated at the margins, placed at slightly unequal distances, averaging two or three intervals to the width of the tube. Exterior wall of the tubes with four to six vertical slightly irregular rows of impressed foramena on each face. The angles of the columns are not perfectly in contact, connected by small transverse papillated processes, about as distant as the diaphragms, varying greatly in prominence, and occasionally absent." *

STENOPORA FIBROSA.—*Goldfuss.*

Corallum polymorphous, usually forming cylindrical branches composed of polygonal tubes (usually six in the space of one line,) slightly and irregularly flexuous, nearly straight in the middle, abruptly bending outward to the surface, edges and sides smooth or marked in parts with strong close inequalities of growth, forming tubercles on the angular edges, and wrinkles across the sides; young interpolated tubes, rapidly reaching their full diameter. Substance of the tubes thick, the interior cylindrical, traversed by numerous diaphragms at irregular distances, usually the width of the tubes apart, sometimes in places irregularly crowded. Surface having a net work of polygonal ridges, with an inner concave space, in which is the small round aperture (six in one line usually.)

AMORPHOZOA.

AMPHISPONGIA OBLONGA—*Salter.*

Plate IV., figure 16.—Specimens of this fossil are very abundant in the yellow mudstone on the Deerhope burn. "They appear as compressed, elongate, oblong masses, about one and a half inches long, and one-third of that breadth above. Below they are considerably narrower, and with a blunt rounded base, the general shape being thus somewhat clavate. The lower portion, about one-sixth, which must have been more solid than the upper, is conspicuously different from it; numerous curved radiating bars (hollows in the cast) rise obliquely from the central line, and terminate bluntly with rounded tips on the periphery. Above these, similar but longer, narrower, and straighter radiating bundles occupy the middle of the mass, and between and among these and the more solid masses before-mentioned, numerous fine slender spicula are closely packed. The upper and wider portion is occupied by these small spicula only, which are seen under a glass to be triradiate, with one cusp at right angles to the two others, and bulbous at the point of insertion. They are arranged transversely to the axis, with the straight sides outermost, and the third cusp directed inwards, and are placed so closely in transverse lines parallel to each other, as nearly to cover the surface. From their leaving cavities in decay, they must have been calcareous, not silicious; and the radiating bundles have the same character, and are most certainly the places of close packed groups of spicula, which formed the walls of radiating canals like those of grantia. These strong bundles only occur near the base."—*Salter*.

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* M'Coy's "British Palæozoic Rocks and Fossils."

BRYOZOA.

Ceriopora granulosa.—*Goldfuss*.

Plate IV., figure 15.—This species of ceriopora, which may be a variety of granulosa, from which it differs slightly, is usually of the thickness and length of a common brass pin. The pores are arranged spirally close together, and ten to twelve in each revolution. This species is very pretty when magnified, the markings being sharp and very regular.

Ceriopora granulosa of Murchison's "Siluria" has the pores linear, and arranged not spirally but in straight lines. In this it differs from the Pentland Hills species, which I have put conditionally under granulosa.

Locality, H.

Graptolites priodon—*Geikie*.

Found at Hare Hill.

CHONDRITIS VERSIMILIS—*Salter.*

The only other form I have to mention belongs to the vegetable kingdom, and is that of a sea-weed—*Chondritis versimilis*, (Salter.) This is apparently a true sea-weed, and extremely like some of our recent species. As no other vegetable forms are found, it would lead us to believe that these beds were deposited at a great distance from land; and while some of the beds have, judging from the prevalence of the brachiopoda, been deposited in deep water, others, judging from the prevalence of gasteropoda, have been deposited in shallow water. The specimens I have obtained of this fossil have been found mostly in one of the beds at H, in which the prevailing shells are gasteropoda, so that it seems probable that this sea-weed may have lived on some shoal in mid ocean. Plate IV., figure 20.

Besides the fifty-five species of fossils described in the preceding pages, a number of fragments of fossils belonging to other genera and species have been found; but they have been either ill preserved, or are of such a fragmental nature that the species to which they belong cannot with certainty be given until more perfect specimens are examined. Among these I may mention what appears to be a portion of the carapace of a crustacean, represented in Plate IV., figure 10. It is probably the posterior dorsal corner of one of the valves of ceratiocaris, and further search may disentomb more perfect specimens from which the species may be identified.

Casts of tentaculites are not common, but specimens may sometimes be found at H, along with spines which sometimes resemble the spines of echinoderms.

At the north-east corner of the reservoir specimens of a form resembling the valve of a leperditia, about one-fourth of an inch in diameter, have been found; but as they occur in crumbling shale, good specimens are procured with difficulty.

I found on the west bank of the reservoir one specimen of the carapace of a crustacean, different from the preceding, represented in Plate III., figure 13. It resembles in some respects the more common forms of cipridina. It is probably a new species, and specimens of it should be looked for. Plate IV., figure 11, represents the base of a jaw-foot of pterygotus, natural size and magnified. It was found in the bed at I, and seems to indicate that some species of pterygotus may be found on further search. Mr Salter also found the serrated base of a swimming paddle in some beds a little lower down.

A very prêtty species of orthonota is also occasionally found at G. It is represented Plate II., figure 22, natural size. At I, another species, figure 11, is very abundant.

In plate III., figures 17 and 17 A. represent the internal casts of the dorsal and ventral valve of a brachiopod allied to *Orthis spiroferoides.* No perfect casts showing the exterior have yet been found.

Since the above was in type, I have received the following letter from Professor R. Jones, with reference to the specimen, Plate III., figure 13:—

MY DEAR SIR,—Mr Henry Woodward has kindly sent me a specimen for examination. It is a good and rare fossil, new to me. It is a Cypridina, hardly separable from recent forms, such as Baird, Dana, and others have described, as far as the appearance of this mould of one of the carapace valves will allow us to judge. The vertical indentation across the valve seems to be natural, and may possibly indicate a generic or subgeneric difference. At all events, you would be safe in using it as the basis of a specific name and distinction for the present. Cypridina occurs freely in the carboniferous rocks. Excepting one specimen of an allied form from the lower silurian, this of yours is the oldest I know. It is preserved in the same way as the Zeperdita of the upper Ludlow beds of Shropshire. I congratulate you on having added such a nice fossil to your collection, and on having brought forward so interesting a species for palæozoic times. I have taken its measurement and outline as a memorandum.

Yours very truly,

T. RUPT. JONES.

To G. C. HASWELL, Esq.

TABLE SHOWING THE PALÆOZOIC RANGE OF THE FOSSILS FROM THE PENTLAND HILL SERIES OF THE SILURIAN FORMATION.

	Pentland Hills.	Lingula Flags.	Llandulo Rocks.	Caradoc or Bala.	Llandovery Rocks.	Wenlock.	Ludlow Rocks.
Orthoceras Maclareni, . . .	P. H.					*	
,, politum, (*M'Coy,*) . .	P. H.			*			
,, subundulatum, (*M'Coy,*) .	P. H.			*			
,, species, ...	P. H.						
,, (?) species, . . .	P. H.						
,, tenuiannulatum, (*M'Coy,*)	P. H.						*
Acroculia antiquata, (*Salter,*) . .	P. H.						
Euomphalus funatus, (*Sow,*) . .	P. H.				*	*	*
Platychisma simulans, (*Salter,*) . .	P. H.						
Cyclomena Salteri, (*new species,*) .	P. H.						
Holopella tenuicincta, . . .	P. H				*		
,, obsoleta, ...	P. H.				*		*
Cyrtolites, (*new species,*) . . .	P. H.						
Conularia Sowerbyi, ...	P. H.			*	*	*	*
Creseis Forbesii, ...	P. H.						
Turrilepas Wrightii, ...	P. H.					*	
Lanulocardium elegans, (*Salter,*) .	P. H.						
Orthonota bulla, (*Sow,*) . . .	P. H.						
,, amygdalina, . . .	P. H.						*
,, impressa, (*Sow,*) . .	P. H.						*
Anodontopsis bulla, (*M'Coy,*) . .	P. H.				*		*
,, lucina, (*Salter,*) . .	P. H.						
Ctenodonta obesa, (*Salter,*) . .	P. H.						
,, thracioides, (*Salter,*) .	P. H.						
Merista Maclareni, (*new species,*) .	P. H.						
Rhynconella compressa, (*Sow,*) .	P. H.					*	
,, Pentlandicus, (*new species,*)	P. H.						
,, variety, ...	P. H.						
,, semisulcata, . . .	P. H.						
,, species undetermined, .	P. H.						
Atrypa reticula, (*Dalman,*) . .	P. H.				*	*	*
,, species?	P. H.						
Strophomena rhomboidalis, (*Dalman,*)	P. H.				*		
,, applanata, (*Salter,*) .	P. H.				*	*	
Orthis ellegantula, (*Dalman,*) . .	P. H.		*	*	*	*	*
,, reversa ?	P. H.				*		
,, minuta, (*new species,*) . .	P. H.						
Leptæna sericea, (*Sow,*) . . .	P. H.		*	*	*	?	
Pterygotus bilobus, found in a different set of beds about two miles distant,	P. H.						
Pterygotus acuminatus, (*Salter,*) .	P. H.						*
Encrinurus expansa, (*new species,*) .	P. H.						
Phacops Stokesii, (*Edw.,*) . . .	P. H.				*	*	
Zethus Pagei, (*new species,*) . .	P. H.						
Entomis tuberosa, (*Jones,*) . .	P. H.						
,, impendens, (*new species,*) .	P. H.						
Beyrichia Klœdeni, ...	P. H.				*	*	*
Protaster Sedgwickii ? (*Forbes,*) .	P. H.						*
Theca, species undetermined, . .	P. H.						
Petraia uniserialis, (*M'Coy,*) . .	P. H.			*	*		
Favosites alveolaris, (*Goldf.,*) . .	P. H.			*	*	*	*
Stenopora fibrosa, (*Goldf.,*) . .	P. H.		*	*	*	*	*
Amphispongia oblonga, (*Salter,*) .	P. H.						
Ceriopora granulosa ? (*Goldf.,*) . .	P. H.					*	
Graptolites priodon, ...	P. H.			*	*	*	*
Chondrites versimilis, . . .	P. H.						
			3	9	17	15	15

CONCLUSION.

THE foregoing table contains a list of the fossils from the Pentland Hills, and opposite to each species I have put a series of asterisks to show the palæozoic range of the fossil, as it is only from a careful study of such a table that the age of these beds can be ascertained. On looking over this table, the first thing which strikes the eye is the great number of species found in these beds which are not found in the silurian beds of England. No less than twenty-five of the fifty-two species found in the Pentland Hills are not found in the typical district of Siluria, leaving twenty-seven species whose palæozoic range is ascertained in the Ludlow rocks, Wenlock shale, Llandovery rocks, Caradoc or Bala, Llandeilo rocks, Lingula flags; so that, by counting the number of species found in the Pentland Hills, belonging to each of these six divisions of the silurian formation, we may form an approximate estimate of the age of the Pentland Hill strata. We find that fifteen of the list are found in the Ludlow rocks, and fifteen are found in the Wenlock, and nineteen of them are found in rocks older than the Wenlock. There are ten species which are never found higher up than the Wenlock, and there are five species which range from the Ludlow upwards.

The most abundant fossil in the beds at H is the *Leptæna sericea*. So abundant are they that they exceed in number of specimens all the others put together. This is a lower silurian form, occurring in the Llandeilo, Caradoc, and Llandovery rocks. At I it is not found at all; and while in H there are found twenty-six species of fossils, and ten species of which occurred at I, there are only two species which occur in both beds.

From this we might draw the following conclusions regarding the age of the series:—First, that they have probably formed part of a different and separate basin of deposit,* and have been divided from the English basin by an isthmus, something in the same way as the Gulf of Mexico is separated from the Pacific Ocean by the Isthmus of Darien, thus rendering it very difficult for species living in the one basin to travel into the other. Second, that, as in the mudstone at H in the map, there is the greatest majority of species belonging to the Wenlock shale, that bed has most probably been deposited during the same period as the Wenlock shale. This is Sir Roderick Murchison's opinion regarding the age of this series, as expressed in his last edition of his "Siluria," in which he says, page 170, after referring to the difficulty of determining the age of these beds from their stratigraphical arrangement—" They have, however, afforded some casts of orthoceratites; one of which, found by Mr Maclaren, most resembles a Wenlock species. More recently, Mr Geikie, of the Geological Survey, has found the *Rhynconella compressa*, also of Wenlock age."

Notwithstanding this strong opinion expressed by the chief of the Geological Survey, Mr Salter, in the appendix to sheet 32, endeavours to show that these beds of the Pentland Hills are the equivalents of the upper Ludlow rocks of Lesmahagow; but the fossils of the Lesmahagow district are all upper silurian forms, whereas very many of those of the Pentlands, as we have seen, are Wenlock, and lower than the Wenlock.†

I do not expect that any subdivisions of these beds will exactly

---

* Salter.

† Mr Salter gives a table, in which he endeavours to show that we have in the Pentland Hills the exact equivalent of the Lesmahagow beds. This comparison is founded on very slender data indeed. If the geological student will read the comparison of the beds, as given by Mr Salter, he will find that the Pentland Hill beds differ from their supposed equivalents in a remarkable manner; thus—

PENTLAND HILLS.	LESMAHAGOW.
No. 1. No fossils, dark shale and sandstone.	No. 1. Certiocaris, shales.
No. 2. Dictyocaris, shale and sandstone.	No. 2. Do., shales and sandstone.
No. 3. No fossils, sandstone, shale, sandy shale, &c.	No. 3. Many crustaceæ, dark-blue gray shales.
No. 4. Fifty species of fossils, mudstone, sandy grit, &c.	No. 4. Lingula and trochus only.

This comparison is of such a vague nature that it does not carry conviction with it; and I would advise all geologists to satisfy themselves by an examination of the district. If they are the equivalents of the Lesmahagow, they must have been deposited in a separate basin.

correspond with the lower Ludlow or Wenlock beds, because, as I have already said, these beds were probably formed in a separate basin of deposit from those of England, and what is very curious, the fossils are not even exactly similar to those from any other silurian beds yet discovered; but we may be able to classify the different beds of this series; and geologists would do well to arrange the fossils from the different parts of the sections separately, so that a comparison may be instituted between the fossils from the upper and lower beds, and by ascertaining the palæontological range of each species found in each bed in the Deerhope burn section, we may succeed in determining whether more than one subdivision is here represented, and the probable age of the upper and lower beds of this section. If they arrange their fossils in this way, they will perhaps find several different zones of deposit, each representing a subdivision of the silurian system. The most striking difference is found between the beds at H and I; at H the most abundant fossil is the *Leptæna sericea*, which is not found at I, but is replaced in abundance by *Rhynconella Pentlandicus.*

Such is a short description of these beds, and notice of all the fossils yet found in them, so far as they have been explored; but I have no doubt that many species will yet be added to the list by careful and diligent search. We have merely skimmed the surface, and no excavations have been made in any part of the beds beyond a few feet from the original weathered face of the rock, and there is no doubt that by penetrating further, we may not only discover new species, but clear up many doubtful points in the palæontological history and stratigraphical arrangement of this most interesting subdivision of the silurian formation.

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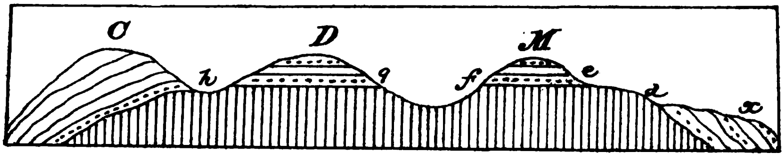
Section No. 1



Section of the vertical Silurian shales capped by the Old Red Sandstone Pent^{d} Hills.

Maclaren

Nº 2

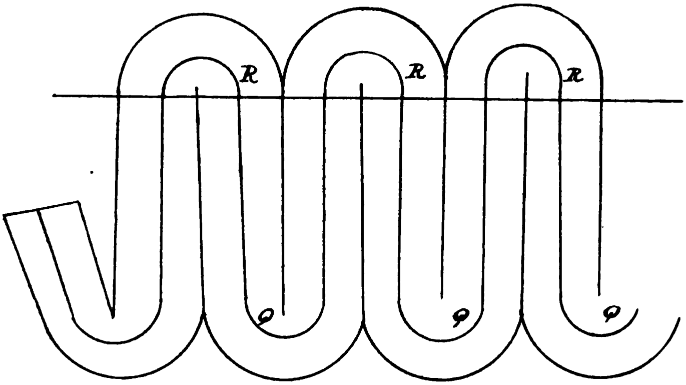


Diagram shewing the manner in which the Silurian strata have become perpendicular.

Plate I.

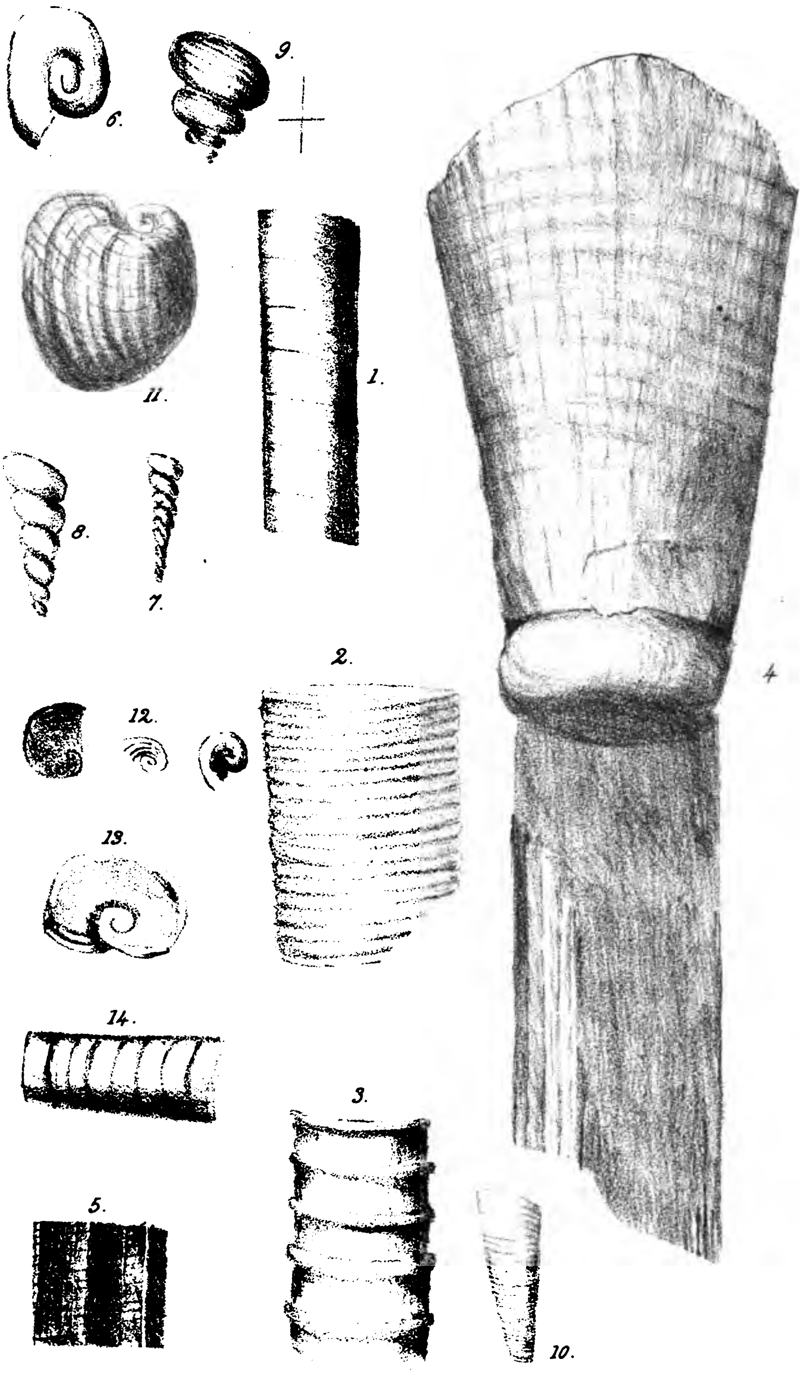


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PLATE I.

CEPHALOPODA.

FIG.

1. Orthoceras politum, (*M'Coy.*)
2. Orthoceras Maclareni, drawing of the original specimen found by Mr Charles Maclaren, and mentioned by him in his Geology of Fife and the Lothians. Now in Hugh Miller's collection in the Industrial Museum, Edinburgh.
3. Orthoceras tenuiannulatum, (*Sow.*)
4. Orthoceras ? or Theca ? Drawing, natural size, of a specimen found by Mr Henderson. This is probably a theca, but the triangular shape is not displayed in any specimen I have seen.
5. Magnified portion of do.
6. Platychisma simulans, (*Salter.*)
7. Holopella tenuicincta, (*M'Coy.*)
8. Holopella obsoleta, (*Sow.*)
9. Cyclonema Salteri, new species, allied to *C. corallii.*
10. Orthoceras, with very close septæ. In Mr Brown's collection.
11. Acroculia antiquata, (*Salter,*) adult specimen.
12. Three small obscure casts of Bellerophon or Goniatites.
13. Maclurea macrothalma ? (*M'Coy.*)
14. Orthoceras subundulatum, (*Portl.*)

PLATE II.

Fig.

1. Conularia Sowerbyi, (*Defrance.*)
2. Creseis Forbesii ? This specimen is very like a creseis; it may, however, be a theca; but the triangular shape is not seen.
3. Anodontopsis species.
4. Cyrtolites, new species ? (*Salter.*)
5. Ctenodonta obesa, (*Salter.*)
6. Ctenodonta thracioides, (*Salter.*)
7. Orthonota bulla, (*Salter.*)
8. Theca, (*Geikie.*)
9. Anodontopsis lucina, (*Salter.*)
10. Anodontopsis bulla, (*M'Coy.*)
11. Orthonota ? Natural size. Probably the species referred to by Mr Salter, page 140. *Mem. Geo. Survey,* Sheet 32.
12. Orthonota amygdalina.
13. Orthonota prora ?
14. Orthonota impressa, (*Sow.*)
15. Rhynconella species. Obscure specimen; but even in its obscurity evidently different from any other specimen found here.
16. Merista Maclareni, new species.
17. Leptæna sericea, (*Low.*)

17 A. A cast of the interior of the dorsal valve, showing the muscular impressions, enlarged.

18. Strophomena applanata, (*Salter.*)
19. Orthis ellegantula, (*Dalman.*)
20. Pterygotus bilobus, specimen of body rings from the north-west slope of the Pentland Hills, near to Bavelaw.
21. Protaster Sedgwickii, (*Forbes,*) figure given by the Geological Survey.

Plate II.

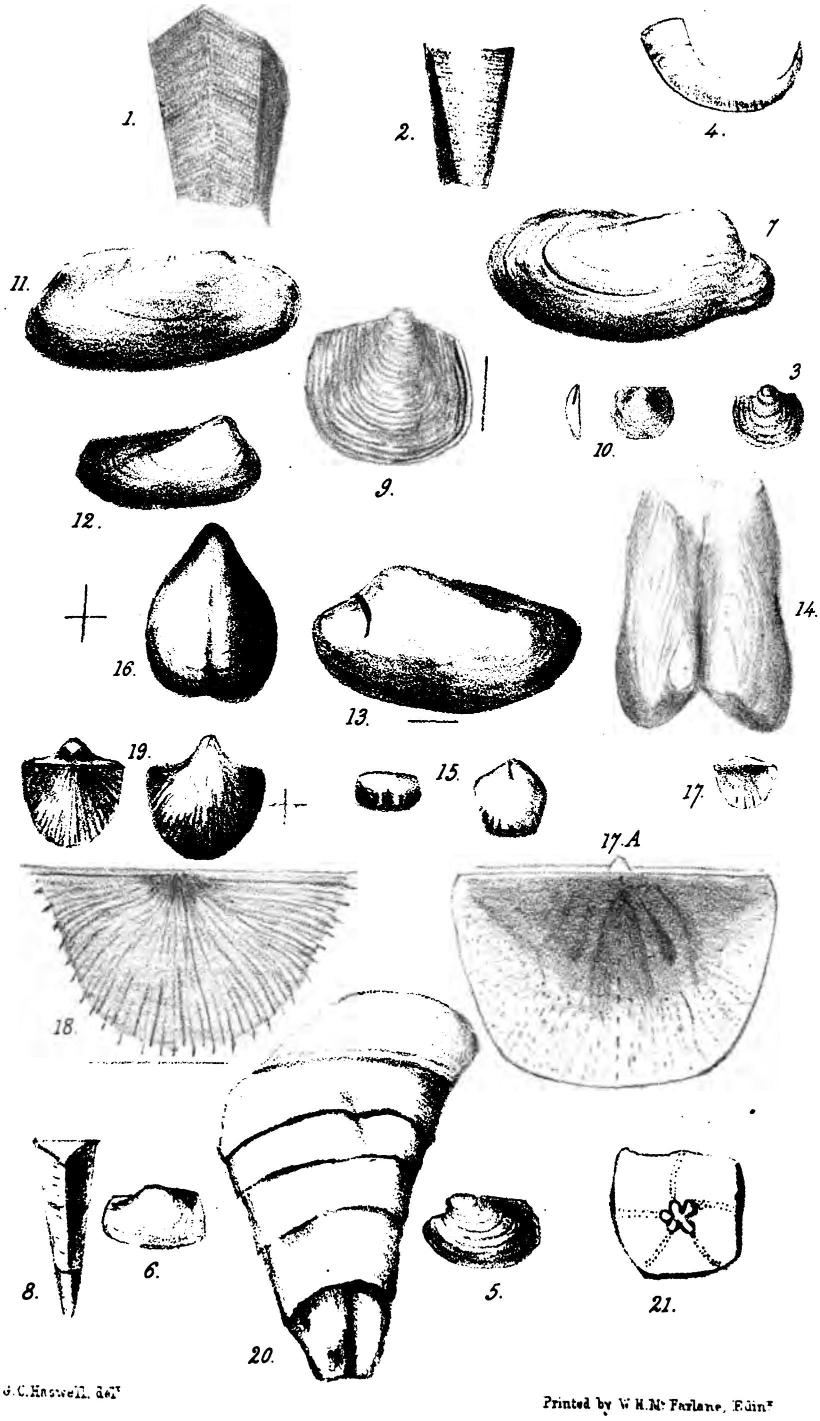

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Plate III.

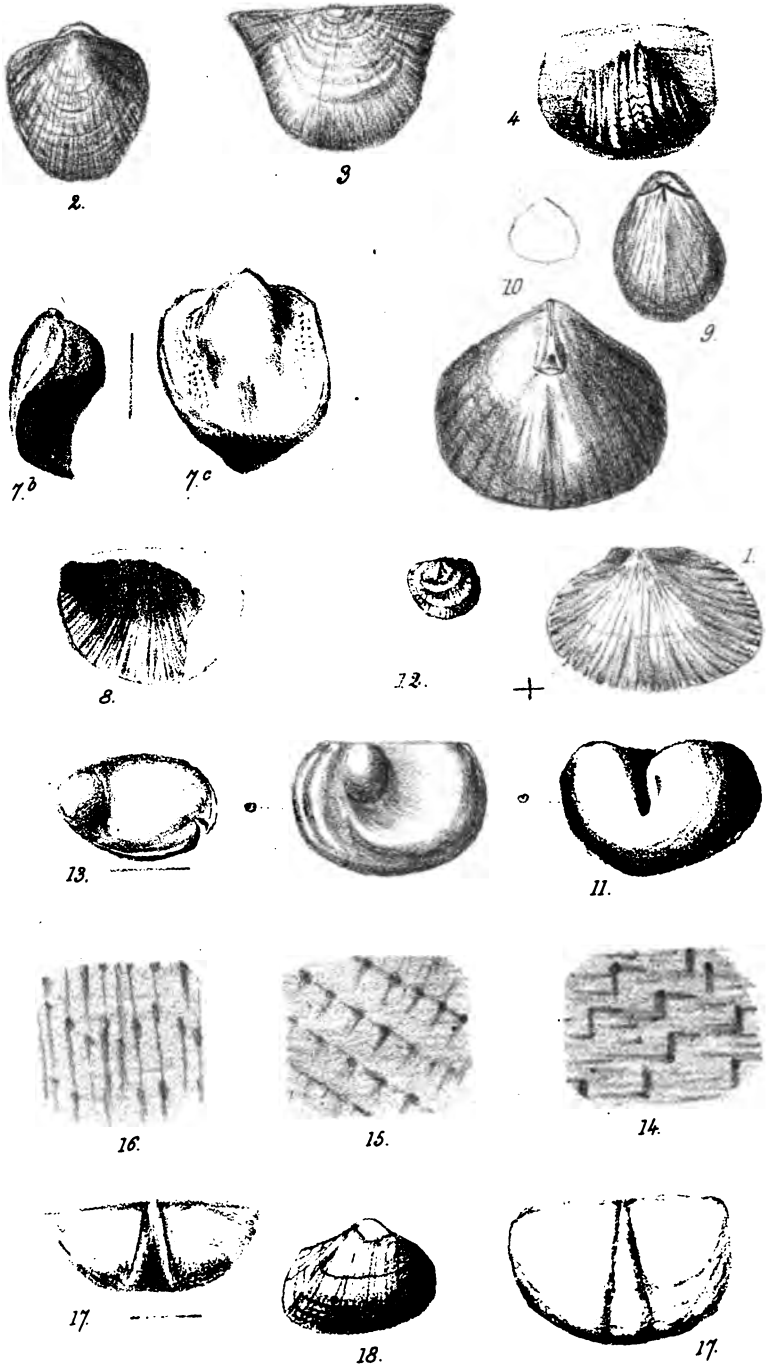

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PLATE III.

FIG.

1. Orthis minuta, new species, magnified five diameters.
2. Atrypa reticularis, (*Linn.*) natural size.
3. Strophomena rhomboidalis.
4. Rhynconella semisulcata, (.)
5.
6. Atrypa, species distinct, but imperfect specimen.
7. Internal cast of Atrypa reticularis, (*Linn.*)—7 *b* and *c* side and front views of the same.
8. Orthis Mitchelini, vel. reversa ?
9. Rhynconella Pentlandicus.
10. Rhynconella Pentlandicus, variety.
11. Entomis impendens, new species.
12. Beyrichia Klœdeni, (*M'Coy.*)
13. Carapace of a crustacean, allied to Leperditia, probably a new species.

14, 15, 16. Amphispongia oblonga ; different appearances according to the direction in which it is broken under the microscope.

17. Orthis spiroferoides ? Cast of the interior of the ventral valve.

17 A. Cast of the interior of the dorsal valve. Mr Thomas Davidson thinks that this may be Orthis spiroferoides, but thinks more perfect specimens are necessary.

18. Lunulocardium elegans ; figure given by the Survey.

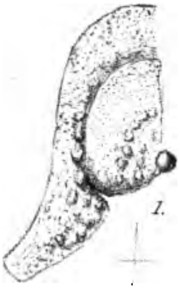
PLATE IV.

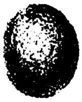
Fig.

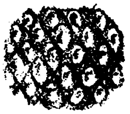
1. Zethus Pagei, portion of the cephalic shield usually found, with the eye very prominant, magnified two diameters, new species.
2. Eye of ditto, magnified twelve diameters.
3. Portion of ditto, highly magnified.
4. Encrinurus expansa; new species.
5. Side view, showing the convexity of the cheeks.
6. Phacops Stokesii, (*Edw.*,) pygidium; specimen badly preserved.
7. Eye of Phacops, from the sandstone at G. Found by Mr Powrie.
8. Encrinurus variolaris; part of pygidium.
9. Part of the jaw-foot of Pterygotus.
10. Ceratiocaris ? a portion of the carapace.
11. The jaw-foot of Pterygotus, showing the serrated base.
12. Turillepas Wrightii ? (*H. Woodward.*)
13. Markings on do., magnified.
14. Petraia uniserialis ?
15. Ceriopora granulosa, (*Goldf.*)
16. Amphispongia oblonga, (*Salter.*)

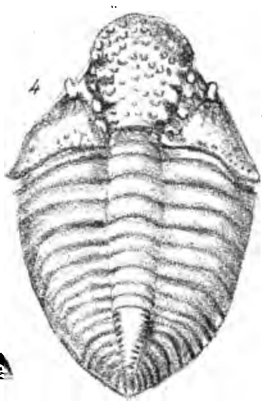
17 and 18. Favosites alveolaris.

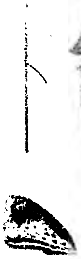
19. Portion of do., magnified.
20. Chondritis versimilis, (*Salter.*)

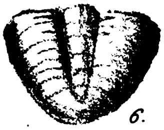


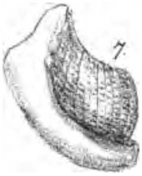


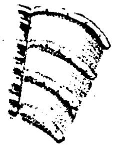


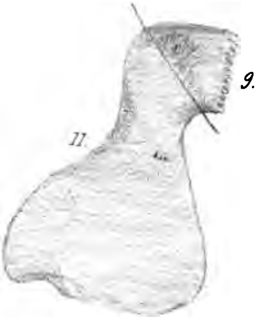


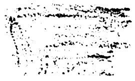


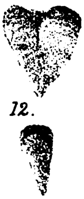


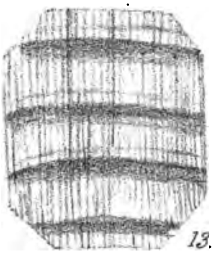


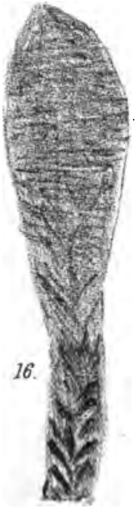


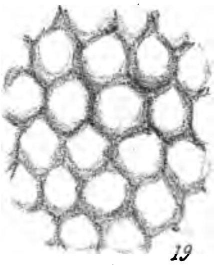


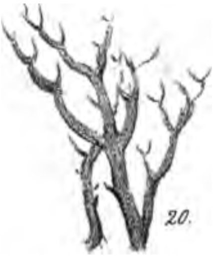


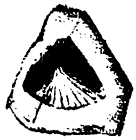












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